# Operation and Maintenance of Electrical Distribution Systems in Health Care Facilities

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# Introduction to Electricity:

- Electricity - The flow of electrons.
- Common terms:
  - Current - The flow of electrons from atom to atom. Measured in Amperes. Similar to volume of water.
  - Voltage - Force applied to a conductor to free electrons, causing electric current to flow. Measured in Volts. Similar to water pressure.
  - Impedance - The restriction to the flow of electrons. Measured in Ohms. Similar to “head pressure”.

- continued -

# Introduction to Electricity:

## Power and Energy.

- Watts / Kilowatts - Standard measure of electrical power. True or Real Power is measured in watts (W) and is the power drawn by the electrical resistance of a system that does useful work.
- KWHr is a measure of the energy used.
- VARS / KiloVARS - Reactive Power is measured in volt-amperes reactive (VAR) and is the power stored in and discharged by the inductive motors, transformers or solenoids.
- VoltAmperes / Kilovolt-Amperes -Apparent Power is measured in volt-amperes (VA) and is the voltage on an AC system multiplied by all the current that flows in it. It is the vector sum of the true and the reactive power.

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# Voltage Classes

- Low Voltage
  - 0 - 600 V
- Medium Voltage
  - 2400 V - 38 kV
- High Voltage
  - 69 kV and above

Note: Voltage from 601 to 2399 and 39kV to 68 kV seldom if ever used.

# System Protection

- OVERCURRENT - Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault.
  - OVERLOAD - Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating.
  - SHORT CIRCUIT - A flow of electrical current directly between circuit conductors, either line-to-line or line-to-neutral, which typically results in high levels of current and arc flash.
  - GROUND FAULT - A flow of electrical current from normal system components to ground typically resulting in high levels of current and arc flash.

# System Protection

Different Conditions * Different Responses

- Overloads — Slow & Deliberate
- Short Circuit — Fast
- Ground Faults — Fast

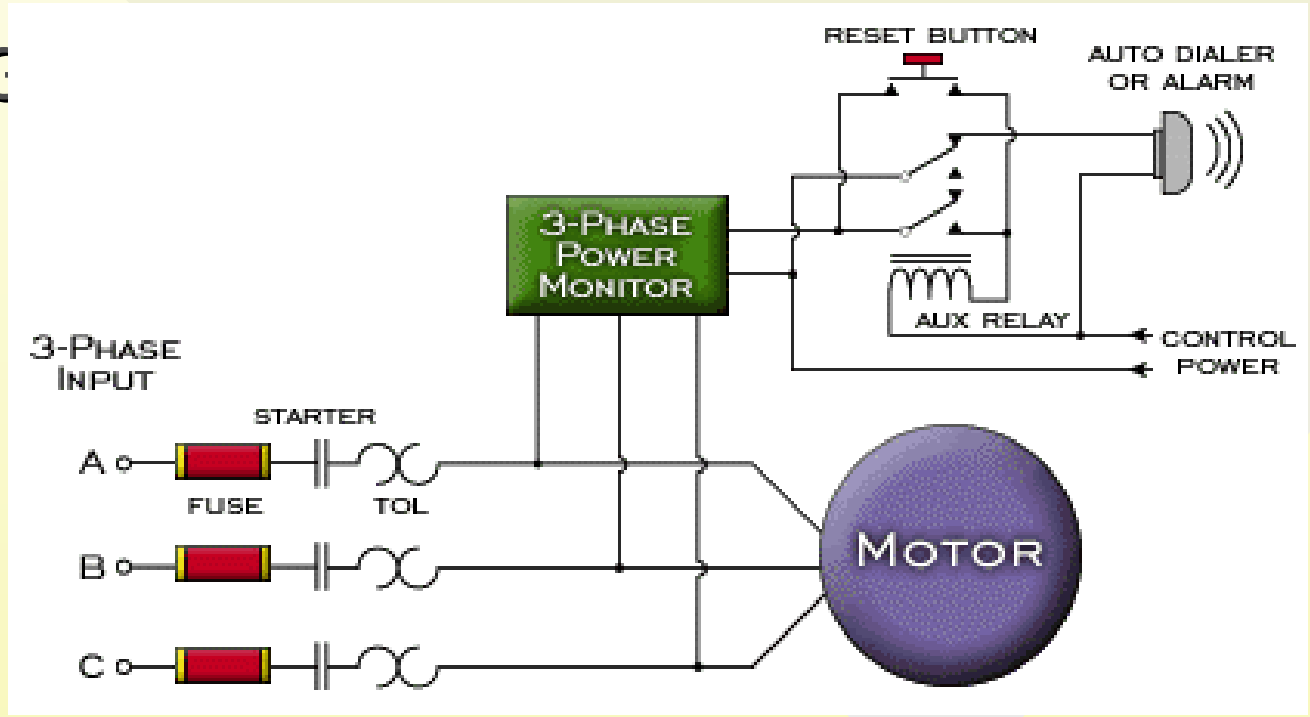
# System Protection

- UNDERVOLTAGE - Can result in damage to motors from overheating due to high current flow to motors .
- OVERVOLTAGE - Can result in damage to motors and other devices from exceeding the dielectric strength of insulators and impacts on various operating components .
- SINGLE PHASING - Three phase systems can lose just one of the three phases and continue operating in an undesirable manner. Motors will continue turning and “generate” the missing third phase. Considerable damage can result.

# System Protection

## Different Conditions * Different Responses

- Overloads
- Short Circuit
- C



# System Protection

- Engineering Studies
  - Short Circuit Analysis
    - Perform engineering study to determine if protective devices are adequate to clear fault currents.
  - Coordination Analysis
    - Perform engineering study to determine the settings and sizing of protective devices to ensure the device closest to the fault will clear.

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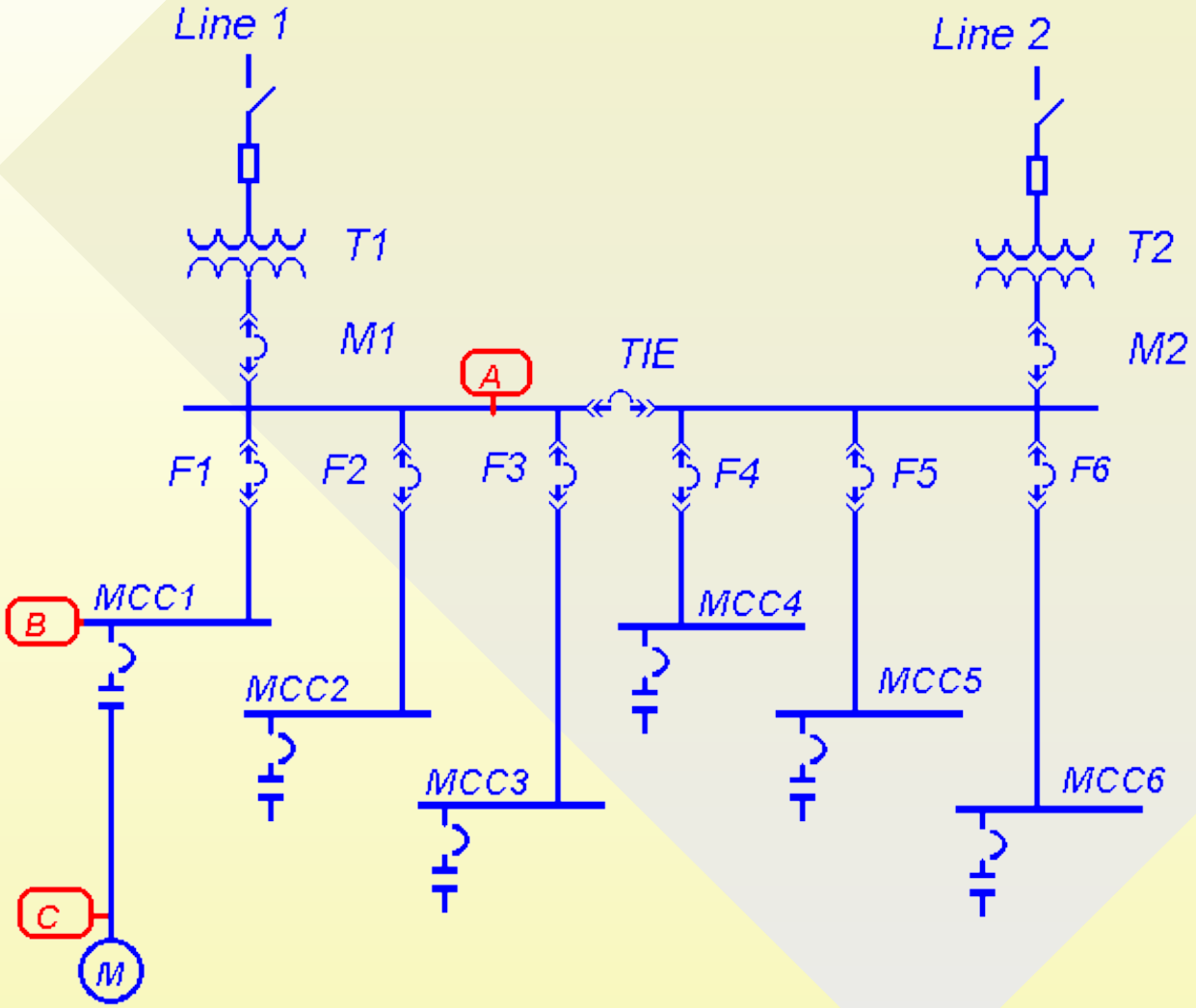
# Typical Double-Ended Service



# O & M Challenges:

- Primary concern is safety - not comfort
- Downtime and Switching Inconvenience
- Undue Corporate Fascination with Complexity
- Inadequate Data Availability
  - File Administration
  - Metering
  - “As-Built” Documentation
  - Unreliable One-Line Diagrams of System

# O & M Considerations:

- Repair or Replace?  Switchgear?  Cables?
- Age and Condition of Equipment
- Previous Modifications
- Proper Testing
  - Right Questions
  - Right Tests
- Future Use Plans
- Hospital or Clinic

# Essential Electrical System: (EES)

- **Essential Electrical System (EES).** A system comprised of alternate sources of power and all connected distribution systems and ancillary equipment, designed to ensure continuity of electrical power to designated areas and functions of a health care facility during disruption of normal power sources , and also to minimize disruption within the internal wiring system.

# EES - Three Branches:

- **Life Safety Branch.** A subsystem of the emergency system consisting of feeders and branch circuits, meeting the requirements of Article 700 of NFPA 70, *National Electrical Code*, and intended to provide adequate power needs to ensure safety to patients and personnel, and that is automatically connected to alternate power sources during interruption of the normal power source.
- **Critical Branch.** A subsystem of the emergency system consisting of feeders and branch circuits supplying energy to task illumination, special power circuits, and selected receptacles serving areas and functions related to patient care and that are connected to alternate power sources by one or more transfer switches during interruption of normal power source.
- **Equipment System.** A system of feeders and branch circuits arranged for delayed, automatic, or manual connection to the alternate power source and that serves primarily 3-phase power equipment.

# EMERGENCY POWER SYSTEM TESTING :

- See paper from HFO summarizing requirements.
- Requirements differ from standard BCE monthly generator testing.
- Use transfer switches, not circuit breakers, to initiate load tests on monthly basis.
- Use circuit breakers only once a year. This also exercises the breakers.
- Develop spreadsheet to document testing of all ATSs.

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# EES REFERENCES :

- Chapter 4 of NFPA 99, *Standard for Health Care Facilities*
- Article 517 of NFPA 70, *National Electrical Code*
- NFPA 110, *Standard for Emergency and Standby Power Systems*
- NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*
- MIL-HDBK 1191

# Visual Observation of Equipment and Ambient Conditions

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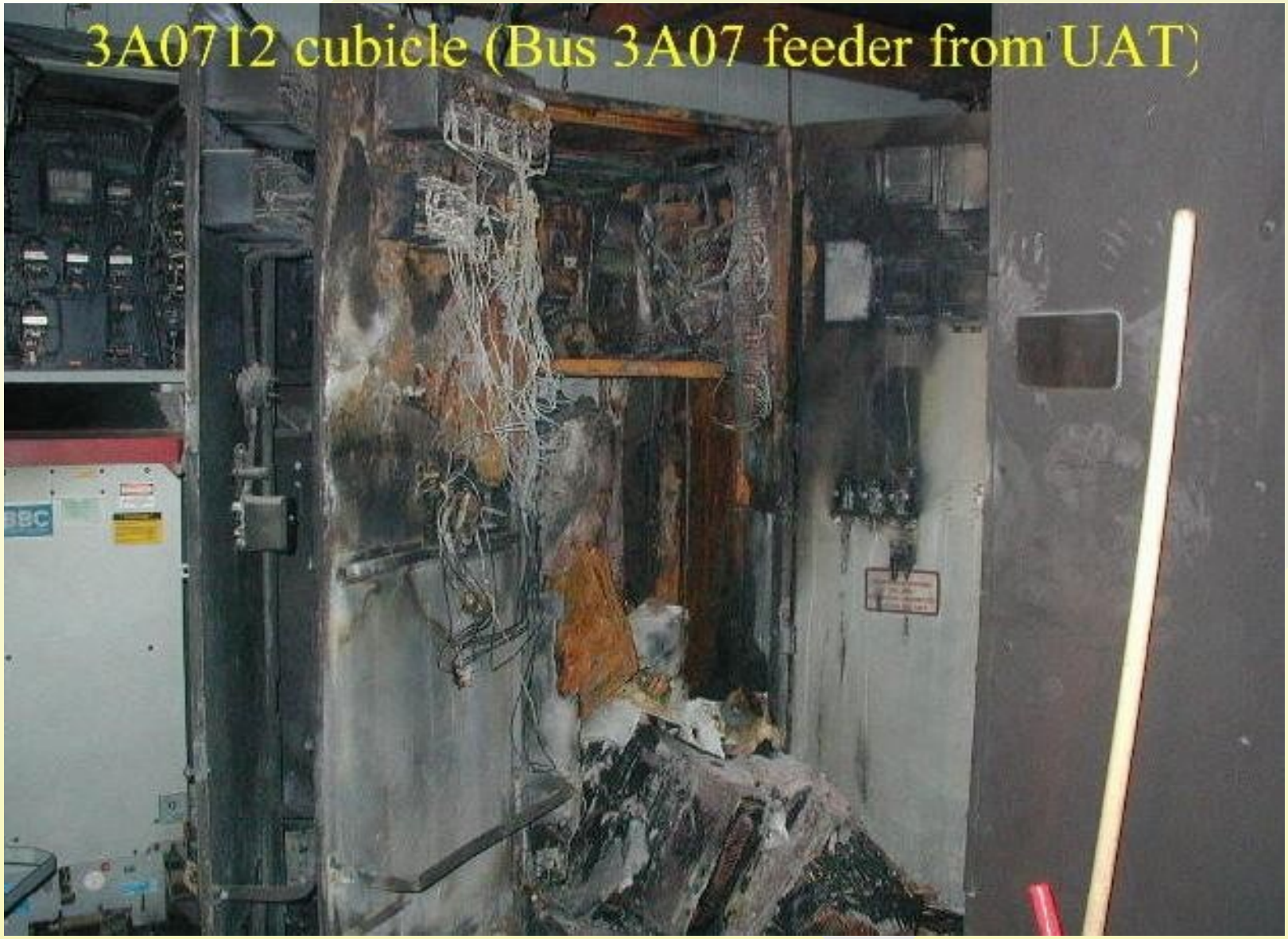
# Electrical Equipment Explosion



# Good Housekeeping

# Typical Thermalscan Report

| Component | Normal Emer. Power Fuse Disc. Panel GEH1 |
|---|---|
| Location | Generator/Mechanical Room |

**Temperature Information**

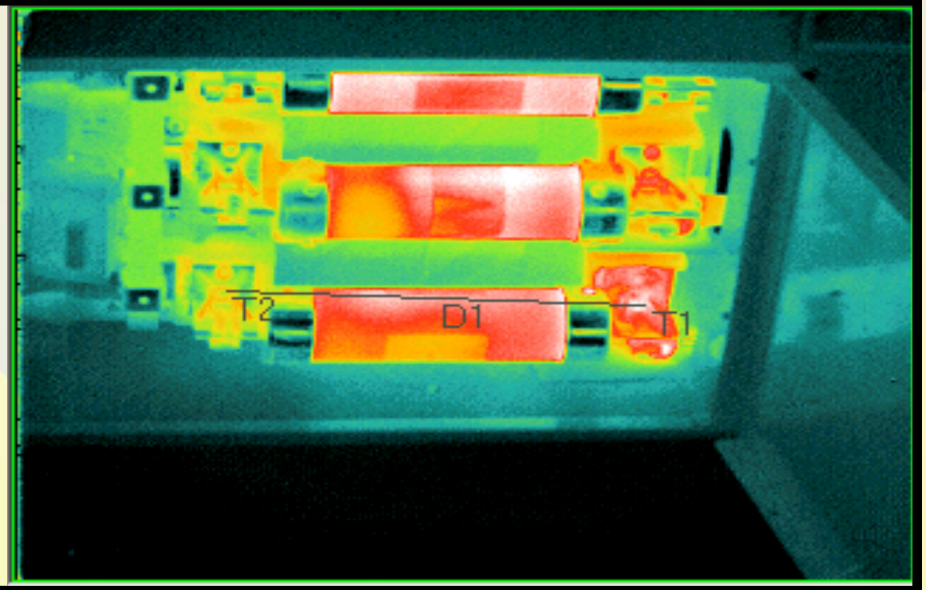
Delta-T (°F)

| ID | Delta-T | Temp1 | Temp2 | Em1 | Em2 |
|---|---|---|---|---|---|
| D1 | 16.65 | 107.39 | 90.74 | 0.93 | 0.93 |

Save Data... Save Points... Load Points...

**Repair Class: 2**

**Thermal Image**

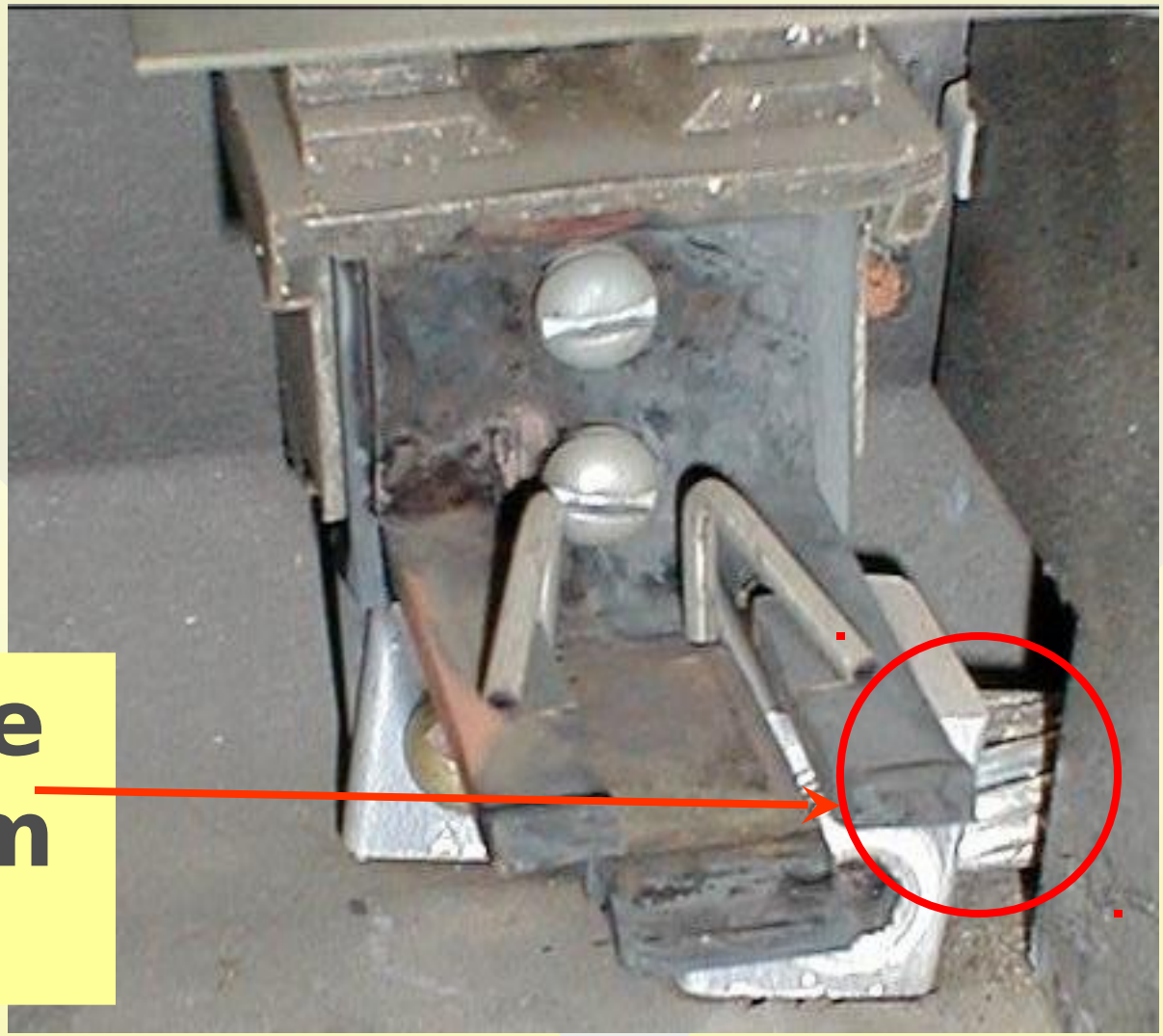



| Comments | Clean, Inspect and Tighten Fuses and Clips. |
|---|---|

# Generator Panel Fused Disconnect

- **Thermalscan detected bad fuse clip connection**

# Base for Fuse Clip



- **Note the Aluminum Wire**

# Thermalscan Image after Action Taken

| | |
|---|---|
| **Component** | **Normal Emer. Power Fuse Disc. Panel GEH1** |
| **Location** | **Generator/Mechanical Room (Fuse and Clip on C Phase clean and replaced)** |

**Temperature Information**

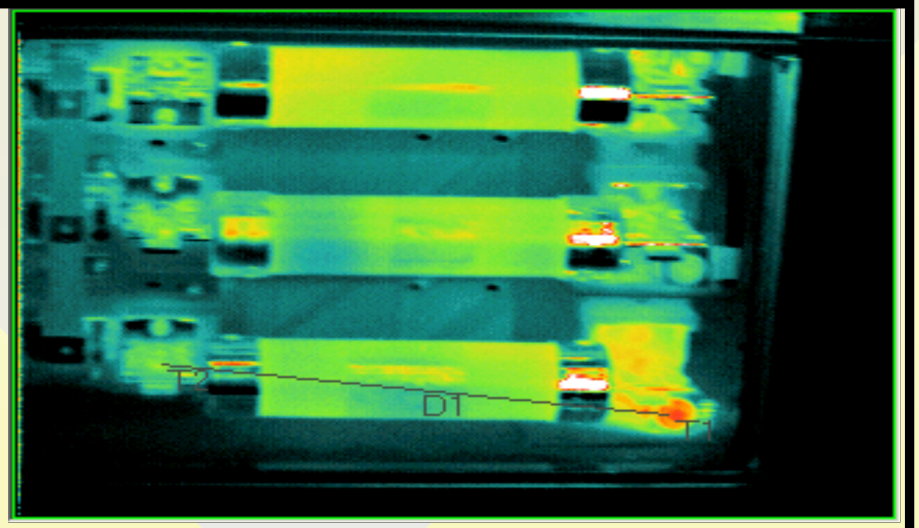
Delta-T (°F)

| ID | Delta-T | Temp1 | Temp2 | Em1 | Em2 |
|---|---|---|---|---|---|
| D1 | 13.46 | 112.94 | 99.48 | 0.93 | 0.93 |

Save Data... Save Points... Load Points...

**Repair Class: 1**

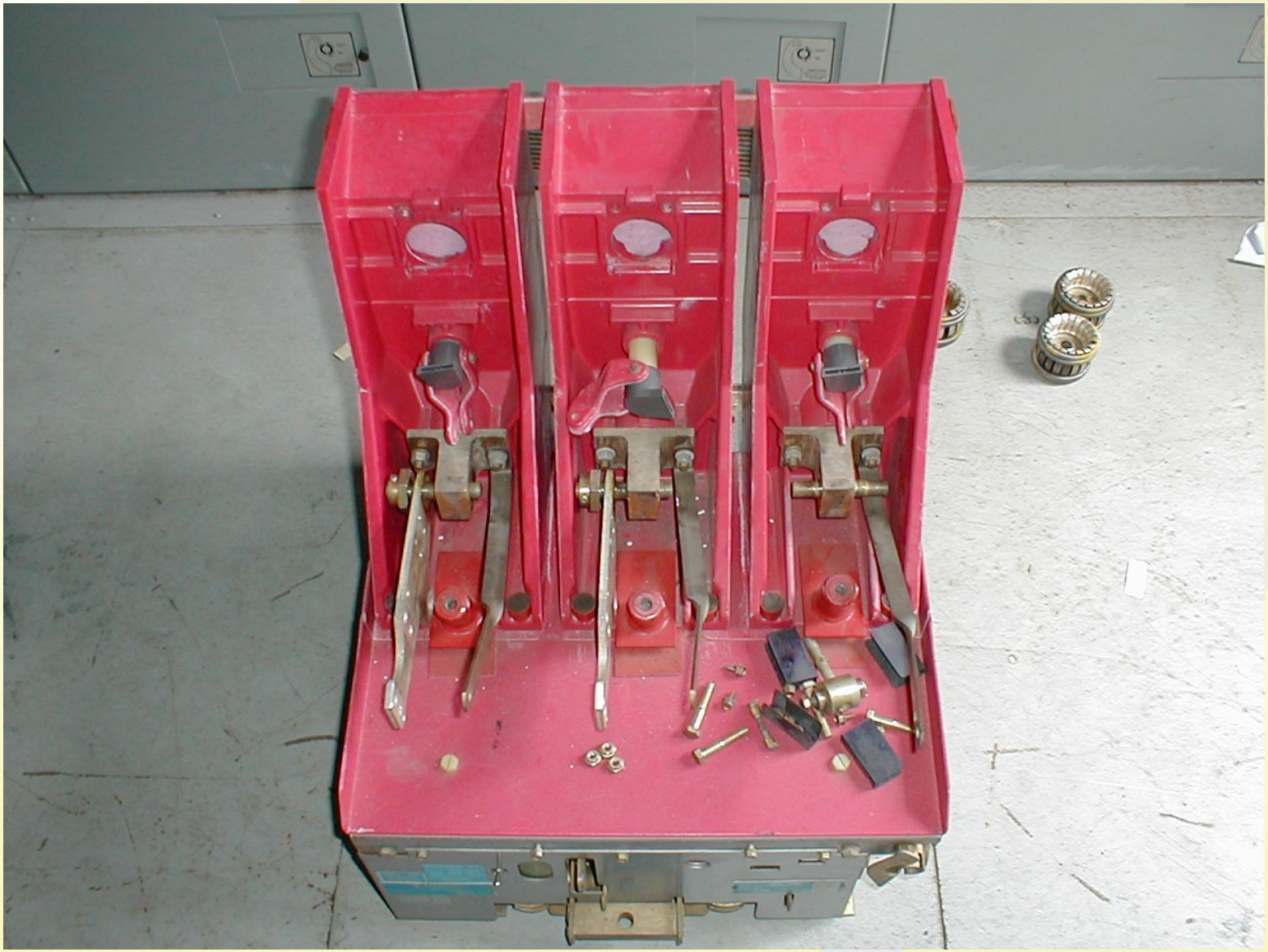
**Thermal Image**




| | |
|---|---|
| **Comments** | **Replace with new C Phase Fuse and Clip.** |

# Test, Inspect, Clean,

# Broken Rocker Arm



# Fire Alarm System

- Annual Test and Inspect
  - Chapter 7, NFPA 72 National Fire Alarm Code

FIRE ALARM RECORD TAG
STAFFORD TECHNOLOGY GROUP
STG
EB6685 / ECA000209
1412 INTREPID DRIVE
DELAND, FLORIDA 32724
(904) 736-0906
Approved
UNDERWRITERS LABORATORIES
S-2766
SIGNAL SYSTEM CONTROL UNIT
1 OF 1
NO. AH-6185
"THIS DEVICE HAS BEEN VERIFIED TO COMPLY WITH FCC RULES PART 15, OPERATION IS SUBJECT TO THE TWO FOLLOWING CONDITIONS: (1) THIS DEVICE MAY NOT CAUSE RADIO INTERFERENCE, AND (2) THIS DEVICE MUST ACCEPT ANY INTERFERENCE RECEIVED INCLUDING INTERFERENCE THAT MAY CAUSE UNDESIRED OPERATION."
MADE IN U.S.A.
121575

# CODES SET *MINIMUM* STANDARDS

# Codes and Standards

- **UL** - Underwriters Laboratory.
  - Non-profit, independent product safety testing organization
- **NFPA** - National Fire Protection Agency
  - Non-profit, world wide agency providing fire, electrical and life safety to the public through developing codes and standards, research, training and education.
- **NEC -** National Electrical Code
  - A set of electrical installation standards applicable throughout the U.S. and published by the National Fire Protection Association. The NEC works with UL requirements and usually carries mandatory compliance.

# Codes and Standards

- **ANSI** - American National Standards Inst.
  - Non-profit organization that facilitates the development standards by establishing consensus among qualified groups.
- **IEC** - International Electrotechnical Commission
  - Non-profit, world organization that prepares and publishes international standards for all electronic and related technologies.
- **IEEE** - Institute of Electrical and Electronic Engineers
  - Non-profit, technical professional association publishing standards for electrical, electronic and related technologies.
- **NEMA** - National Electrical Manufactures Association
  - Provides forum for a standardization of electrical equipment ensuring products are competitively priced, able to perform predictably and are safe

# FRIEND OR FOE?